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RESULTS AND EXPERIENCE GAINED DURING 1950
IN MANUFACTURE OF ELECTRIC MOTORS

Gyorgy Fischer

[Figures are appended.]

The following is a brief description of the chief results attained during 1950 at the Ganz Electrical Equipment Factory.

Small and Medium-Sized Alternating-Current Motors

Many induction motors differing from the serially-produced type were designed and manufactured during 1950; most of them will be used to power machine tools. These include medium-sized totally enclosed motors, some of which are built to withstand gas under pressure for safe operation in mines. Four such motors will be installed in the new mine-broaching combine, two of which will be squirrel-cage induction motors, including one with slip rings attached to the stator and with a compound-wound rotor. The motors for the combine are now nearly completed.

The first samples of the new totally enclosed, externally ventilated motor series were completed in 1950. The models manufactured at present are a series of four-pole motors, ranging from 4 to 200 horsepower; a six-pole, 180-horsepower, 380-volt model; and an eight-pole, 300-horsepower, 3,000-volt model.

It was also necessary to make changes in older models. Two-pole mine motors had to be delivered in such short time that delivery was retarded until faster methods of winding the poles were developed.

The quality and precision of small electric machines were greatly improved by installing vertical lathes and turret lathes in motor manufacturing plants. The installation of new tracing lathes reduced the production time for axles by 56 percent. New methods have cut winding time 10-15 percent, and a new vacuum impregnation method has greatly improved the insulation of motor parts.

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Direct-Current Motors

New developments during 1950 in the field of direct-current motors included the following:

A new-type 1,100-horsepower, heavy-duty, reversible motor was developed for transport work in mines. A new type 600-horsepower generator was developed for diesel-electric switching locomotives. There is no journal between the latter generator and the diesel engine which power it. The power is transmitted by means of a ball-and-socket connection, consisting of a sphere connected to the generator, which fits into a hollow in the axle of the diesel. The rotational force is transmitted from the diesel flywheel to the axle of the generator by means of a rubber block universal joint which surrounds the socket. Ward-Leonard type motor cars are being built for railroad locomotion. In manufacturing the main generator for these cars, difficult problems were encountered in the production of the commutator, which is approximately one-half meter in diameter and which has a speed of 2,100 revolutions per minute.

A single-unit drive motor was developed for various types of switch engines designed for special operations, which permits reduction of maintenance costs of these engines to a minimum.

In preproduction tests, it was discovered that the commutator bearings of a traction motor of one locomotive type were continuously overheated by the magnetic field surrounding the leads connecting the main and secondary pole windings. This was corrected by separating the leads connecting the windings. Many other direct-current motors for diesel-electric locomotives and for suburban electric trains were designed during the year.

Electric motors used on ships were also standardized, with some changes made in design, according to the special requirements of river traffic.

A new-type power transformer was built for the chemical industry. The transformer operates at 3,000 amperes and 90 volts.

Many problems concerning the new motor coaches and the diesel-electric locomotive are still unsolved. Most direct-current motors being designed and built at present are intended for the Danube Iron and Steel Works (at Dunapentele) and range from small fan motors to a prime mover for a rolling mill with a moment of 300 ton-meters and weighing 250 tons.

Locomotive Motors and Large Induction Motors

The chief project during 1950 in the field of large induction motors was the development of the 50-cycle electric locomotive motor which will be put into serial production between the 3d and 5th years of the Five-Year Plan. The traction motors of the locomotive are unusually light due to an expert use of construction materials. Although their electrical characteristics are the same, the weight of the new motors, 2.8 kilograms per horsepower, is much less than that of ordinary induction motors.

The development of Hungarian mines made it necessary to modernize older types of mine motors. As a result, the cost of the motors was reduced, without impairing the output. In heavy industry, changes were made in the construction of motors of several thousand horsepower which were being built for Dunapentele, and in the 4,000-horsepower, 4,000-rpm maximum, 2-pole, slip-ring induction motor for turning turbogenerators. Large capacity induction motors with a vertical axle arrangement for pumping water for irrigation, are also being built.

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Large Generators

The scope of the Three-Year Plan provided many possibilities in the field of designing multipole generators, and the possibilities have been increased by the Five-Year Plan. Development is proceeding along two lines: modernization of medium-sized generators, and the development of new, high-power motor types for power plants and industrial sites whose construction is encompassed by the Five-Year Plan.

The new motors will form part of an entire new series which will be established later. Problems which arose in building up this series can be solved only through cooperation between the factories manufacturing the motors which drive the generators, and through national standardization of the electrical machinery. The first step in standardization is the establishment of a graduated scale of motor capacity according to the number of pairs of poles. Three generators included in the plan, which are the prototypes of a new series, were completed in the first year of the plan. Completion of these generators also provided basic information for future implementation of the series.

Among the problems of designing and planning are the recently completed medium-size, middle frequency (1,000 cycles per second) generators for induction furnaces. These generators presented entirely new problems, such as devising new methods for carrying out, the calculations necessary for their manufacture. Also, foreign-made generators for induction furnaces presented particular problems of maintenance and had recurring faults, such as bearing trouble, which had to be worked out. Improvements were made in the design when the production of such machines was begun in Hungary. Although adequate data is not yet available concerning the practical operation of the first generator which was completed recently, the electrical performance of the generator in the testing room was equal to that of foreign models, and the domestic generator was shown to be superior mechanically, especially with respect to the bearings.

Because of a shortage of water power, the manufacture of large, low-speed generators is less advanced in Hungary than in other countries. One of the problems presented by the sheer mass of the 6-meter-diameter generators for the Tiszaok water power plant, which is one of the power plants scheduled for construction under the Five-Year Plan, is the difficulty of transporting an object of such size by rail. The generator's greatest dimensions exceed railroad profile clearances by 70 percent. Therefore, a laminated rotor was designed, to permit its shipment in sections. This generator provides the first instance in Hungary of the use of laminated pole rotors in electric generators. The design is based on another generator which was completed and tested in the first year of the plan, and which has a horizontally mounted, cylindrical rotor, and is in the upper classes of dimensions and speed. Research in connection with the design consisted of experiments and of perusal of foreign, especially Soviet, literature.

Turbogenerators

Although only one or two turbogenerators of any one design were built in the past, the design of turbogenerators has been sufficiently standardized to permit building many generators of relatively few types.

This has relieved the burden of the design office, so that it could turn its attention to other problems.

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Large sums have been made available for extensive experimentation and research, and the construction of generators of higher power can now be planned. Improvements in design, reduction in operating costs, and reduction of stoppages are also furthered by standardization. Standardization of generators also resulted in improved generator cooling which increases the life of the generator and reduces breakdowns. Increased research has permitted designing machines with as much as 75 percent greater capacity than the most powerful generators previously built. Another result of the research will be large savings in the construction of power plants. The designs for many turbogenerators of various sizes were completed in 1950, incorporating innovations for continuous safe operation. Problems encountered in designing the large generators included durability of materials and construction of the 6,000-rpm rotor; the very high temperatures generated by the rotor; and insulation in the 10,500-volt stator. Even greater problems are to be expected in the development of much larger generators planned for future construction under the Five-Year Plan.

Electric Traction

The principal trend in the field of electric locomotion during 1950 was the development of locomotive types to be mass-produced at a later date. The earliest project along this line was the diesel-electric train. Transmission of power to the driving wheels by electrical means in the 600-horsepower motor units was a unique problem for Hungarian engineers, who previously had only dealt with mechanical transmissions. Many problems of design were treated with only a knowledge of foreign developments as a background. Other special features of the train are its auxiliary electric circuit, electric air-conditioning system and electric kitchen, all supplied by a 240-horsepower motor-generator unit in each end of the train.

Another important development was the placing in operation during the fall of the new 50-cycle (commutator-motor) electric locomotive. The older type electric locomotives operating on the Hegyeshalom line are now more than 20 years old. The design has been improved in the new locomotives by replacing the single traction motor of 3.1-meter diameter and mechanical transmission with ordinary three-phase induction motors installed directly on the drive axles. The speed of the traction motors is regulated by a current of controlled frequency, which is supplied by another three-phase induction motor used as a frequency converter. Compared to the older 2,500-horsepower 98-ton-load locomotive, the new Kando produces 3,200 horsepower with an 89-ton load; and the speed has been increased from 100 to 125 kilometers per hour.

The first 50-cycle, commutator-equipped, electric locomotive developed outside Hungary was completed in 1950. The advantages of the Hungarian locomotive are: the tested reliability of the motor, and the fact that the Hungarian locomotive draws constant power from the line. The average power factor of the commutator-motor equipped locomotive is 0.72.

Plans are almost completed for the electrical equipment of a 50-cycle electric motor coach. The power plant of the coach will consist of a single-phase motor driving a generator which powers the direct-current traction motor. The single-phase motor will be of the synchronous type which has a constant power factor. This vehicle type will play an important role in the electrification of the railroad lines of Greater Budapest.

Another task is the development of another locomotive type in the 600-horsepower diesel-electric class, for heavy switching and for short-distance freight hauling.

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Many new types of coaches are planned for urban and suburban use. Planning work on the modern, high-speed motor coaches for the Csepel express transit line was completed several months ago. A new type streetcar is also being developed for Budapest city traffic. The new streetcar will be a further development of the popular four-axle car now in use, and will have increased passenger capacity and greater power. Preliminary work has been begun on the development of a streetcar type with exceptionally large passenger capacity, for operation on the diagonal streets leading out from the city center. These cars will carry passengers transferring from subway lines.

Trolley buses, running on the surface parallel to the subway, will play an important role in the future. The Hungarian-manufactured trolley buses are patterned after a Soviet model, and standardization of trolley bus parts to conform to the parts of the autobus now in use will result in a saving in manufacturing and maintenance costs.

Coaches for subway trains, which will be modeled after those of the Moscow subway, were studied extensively during 1950. The six-car train will have a motor installed on each axle. This arrangement will result in smooth and rapid acceleration and braking. Through the elimination of brake dust, maintenance cost of electric parts, leads, and signal wiring will be reduced considerably. Manufacture of coaches for the lines now under construction will not make serious demands on the production capacity of the manufacturing plants until 1953 - 1954.

Demands are increasing in the field of mine locomotives, which are in the class of locomotives manufactured serially.

Manufacture of Transformers

Transformers rated at less than 3,200 kilovolt-amperes are being serially produced. Considerable progress was made in the serial production of transformers during the first year of the Five-Year Plan, due to the electrification of villages. Much progress had already been made prior to 1950, but commencement of serial production gave an indication of the possible results attainable through standardizing transformers and transformer parts. This was followed by the establishment of national standards for small transformers through the Standards Affairs Agency. After the standard was approved, the serially produced models were modified with the assistance and advice of the shopmen, resulting in better transformers at lower cost.

Serial manufacture of transformers was also begun in the first year of the Five-Year Plan. Based on tables of standards, a series of transformers was developed, including 3,200, 5,000, 6,000, 8,000, 10,000, and 12,500 kilovolt-ampere models. Previously, every transformer in these classes was designed and built as a special unit. With the development of the new standard models, 20-40 percent of the amount of material formerly used in parts is saved, manufacturing time is reduced, and specifications by consumers are simplified. A 120,000-volt power network is being built under the Five-Year Plan, which will carry up to 132,000 volts at the power stations.

Many unusual problems were encountered in building the network, especially in building the giant transformers. A center-tap secondary with grounded ends made possible the use of the unusual staircase-type insulated diaboloid (double opposed concave) transformer. The essential construction of this transformer is shown in the appended figure. The insulation distance between the low- and high-voltage windings is adapted to the voltage at each point along the magnetic axis; the greater the voltage, the greater the insulation distance. The high-voltage tap is located at the center of the secondary coil. The oil channel between the primary and secondary coils of this transformer type forms an ellipse. In a diaboloid-type transformer, the voltage increases from the ends toward the center of the winding. The two layers of 120-kilovolt end insulation, which would otherwise be necessary in this transformer, can be eliminated, since there is no voltage difference between the ends of the winding and the iron core.

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Elimination of this insulation also permits more effective use of the core, since more copper can be placed within the core and the dimensions of the core can be reduced. Another saving in copper is due to the increased insulation distance of the staircase insulation design, and to the reduction in the average diameter of the windings. The diabola design winding, grounded at both ends, results in much more uniform insulation and permits the distance between the coils to be reduced. This, in turn, permits a decrease in the diameter of the high-voltage coil and in the length of the iron-core yoke, which conserves copper and iron.

Through increased use of active materials and appropriate redesigning of the core, it was possible to employ greater iron-core induction and higher frequency, which also resulted in a reduction in dimensions, weight, and costs. The decrease in the distance between the primary and secondary coils (and this distance is even less at the outer windings of a diabola-wound transformer), results in a reduction in tension across the transformer. Previously, a 100-kilovolt transformer had a short-circuit voltage drop of 10-12 percent, which corresponds to approximately 15 percent in step-up and step-down, or twofold transformation, at the normal power factor. This results in a saving in the output of the generator plant, and permits approximately 15-20 percent more power to be transmitted on the same line.

The new-type transformer, therefore, can be manufactured from less material, at lower cost, and is more advantageous in power transmission. The oil is usually cooled by means of groups of radiator coolers equipped with separate ventilators. The cooler groups are installed in interchangeable batteries, and it is possible to use supplementary coolers in addition to the usual number of cooler groups. After testing, it was found that the number of coolers could be reduced. To permit use in the 100-kilovolt network still remaining, transformers now being manufactured can be adapted to operate at 110-120 kilovolts.

Transformer voltage is regulated independently by the neutral regulator. The elimination of current taps assures complete short-circuit safety. Tests which have been performed assure the quality of the new-model transformer. High-capacity regulating transformers are very important in feeding a power network at constant voltage. These regulating transformers operate through the use of switch taps.

In the manufacture of voltage regulators in Hungary in the past, the emphasis has been on two-core or multicore units, and on transformers for a shunt circuit. More recently, the development of a 10-20-30 kilovolt switch gear and oil breaker has made possible the manufacture of single-core booster and main-line high-capacity regulators. If high-tension, 110-120 kilovolt transformers are attached to grounded y-connected systems, they can be manufactured together with the separate, 30-kilovolt voltage regulator equipped with a circuit breaker, and connected to the open "zero-point" system.

The single-core "zero-point" system voltage regulator made possible a 35 percent saving in material which, despite a comparatively more expensive circuit breaker system, resulted in a significant reduction in price. The power loss of a single-core is about half that of the two-core system, which means a considerable saving to the power supplier. Production was greatly simplified by the introduction of windings which are independent of the transformer load, and of mass-produced high-voltage internal connections. Within normal regulation limits, the regulators are provided with ventilation for operating above 10,000 kilovolt-amperes.

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Manufacture of Electrical Apparatus

Many comparatively inexpensive new types of voltage regulators were produced in 1950. The new regulators have proven entirely satisfactory both in tests and in industrial use.

Early in 1950, the first electric control panels for machine tools were produced [redacted]. The new control panels permit centralization of the electric components machine tools, provide for increased automatic control, and are effecting a great change in the design of machine tools. The 100-kilovolt high-capacity, low-oil-content contactor was also mass produced for the first time in 1950.

During the past year, plans have been completed for a 110,000-volt circuit breaker with considerably greater capacity than previously manufactured types. The new breaker has an interrupting capacity of 2,500,000 kilovolt-amperes, and is reclosed quickly [redacted]. Preliminary manufacture of parts is already under way, and the first complete breakers will be produced in the first half of 1951.

With the increasing output of power plants, the number of types of compressed-air switchgear manufactured has been decreased and production has been increased, stress being placed on the production of larger types [redacted]. As a result, the equipment of the power network and its productivity are being increased.

High-quality silumin castings now replace cast steel in many parts of the new switches.

The following are diagrams of the old-type transformer and of the new diabola winding.

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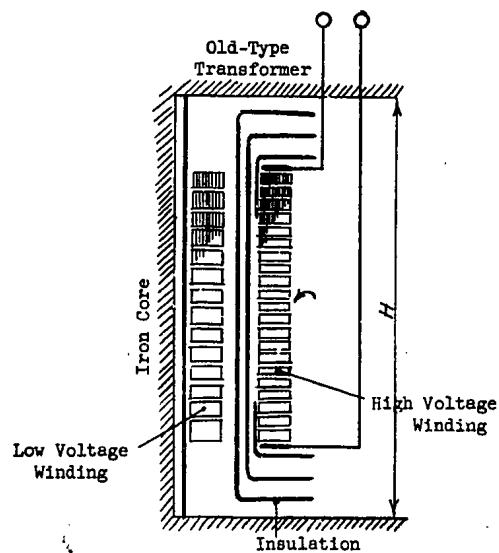


Figure 1

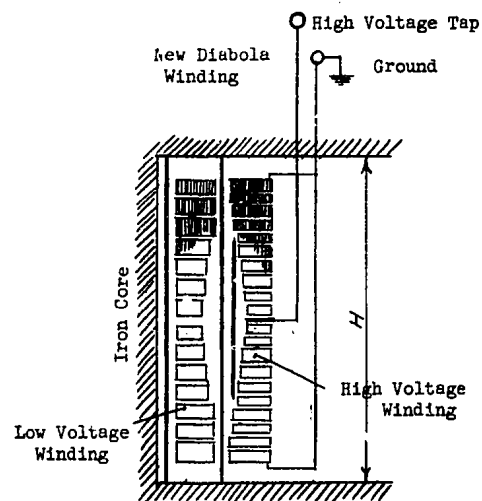


Figure 2

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